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Soil Lichens of the Loess Hills Prairies in Iowa[1]

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Soil lichens occupy a unique niche in drier grasslands. They are usually inconspicuous, but they flourish in the Loess Hills prairies where the vegetation cover is sparse and the exposed soil between the dominant bunch grasses is available for colonization. Of 34 lichen species reported to occur on soils in Iowa, 11 species are well developed in the prairies of the steep, dry, loess slopes. The same species are abundant on upper slopes and gravelly ridges in remnant prairies throughout western and northwestern Iowa. The thalli of these lichens are well adapted for xeric conditions. They are typically small and compact, squamulose to subfoliose, and of gelatinous to leathery consistency. Most are densely rhizinate, enabling them to persist on a substrate highly prone to erosion.
INDEX DESCRIPTORS: soil lichens, loess prairies, *Bacidia* sp., *Caloplaca* sp., *Candelariella* sp., *Cladonia* spp., *Collema* sp., *Dermatocarpon* sp., *Diploschistes* sp., *Endocarpon* sp., *Heppia* sp., *Lecidea* sp., *Thrombium* sp.

Soil lichens occupy a unique niche in the grassland ecosystem and are an intriguing, but much overlooked, component of the state's lichen flora. They represent a significant gap in our understanding of Iowa's lichens because of their occurrence in a habitat (i.e., grasslands) seldom treated by lichenologists and other cryptogamic botanists in floristic surveys. To date, 264 species of lichens have been reported from Iowa, 34 of which occur on soil (Malone & Tiffany, 1978). Within this terricolous group, we have identified a distinctive complement of 13 species that are indigenous to native prairies of western Iowa.

Collections were made at the Iowa prairie sites listed in Table 1 (Figure 1) from 1978 through 1983, with intensive field work in the Loess Hills prairies from 1981 to 1983. Specimens have been deposited in the mycological section of the Iowa State University herbarium.

Locations and legal descriptions for the prairie collection sites are given in Table 1. The 13 lichen species identified are listed in Table 2 along with the sites where they occurred. Taxonomic treatments used in making the identifications included Fink (1910, 1935), Degelius (1954), Duncan (1970), Taylor (1968 a, b), Thomson (1967), Weber (1963), and Wetmore (1967). Nomenclature follows the checklist of the lichens of North America by Hale and Culberson (1970).

We have grouped the species of soil lichens collected from Loess Hills prairies and other Iowa prairie sites on the basis of frequency of occurrence (Table 2). Group I contains the most common and characteristic species of the Loess Hills prairies, *Collema tenax, Dermatocarpon lachneum, Endocarpon pusillum* and *Lecidea decipiens*. These four widely distributed species can be found in exposed grassland sites in western North America and in arid regions throughout the world. They were found in abundance at every Loess Hills prairie site that we sampled.

Species in Group II also have broad geographic ranges but differ from group I species in that they occurred less frequently and less abundantly. *Bacidia bagliettoana, Caloplaca stillicidiorum, Candelariella vitellina, Cladonia apodocarpa, Cladonia cariosa, Heppia lutosa,* and *Thrombium epigaeum* in this category occur in the Loess Hills prairies.

Squamarina lentigera, Group III, is designated separately because it is considered to be a western species. Fink (1935) reported it from Nevada, Colorado, Nebraska, and Montana; Wetmore (1967) collected it from the Black Hills in South Dakota. We found it only on gravel ridges at Cayler Prairie and Freda Haffner Kettlehole, both prairies of the morainal hills at the western edge of the Des Moines lobe in northwest Iowa (Prior, 1976).

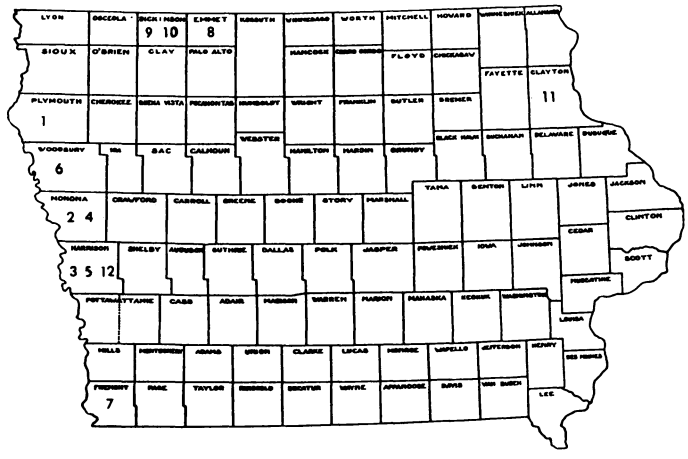

Fig. 1 Soil lichen collecting stations in Iowa.

SPECIES DESCRIPTIONS AND COMMENTS

Group I

Collema tenax (Sw.) Ach.

The thallus is foliose, gelatinous, olive-gray to black, with no internal differentiation or stratification. The radiating plicate lobes strongly resemble the thalli of the liverwort genus *Riccia* and easily could be mistaken as such. When wet, the thallus becomes greatly swollen, and the entire surface is covered by a mass of pulpy isidia. The phycobiont is a cyanobacterium, *Nostoc* sp., with cells in short chains. In our collections apothecia are uncommon; however, when present, they have a deep red-brown disc and hyaline, septate ascospores.

Dermatocarpon lachneum (Ach.) A.L. Sm.

Thalli are fawn to red-brown squamules, 1-4 mm in diameter, with an inner white medullary layer and a dense felt of rhizines covering the lower surface. Margins of the thallus are adnate or ascendant, sometimes shallowly lobed, often white pruinose, especially in older thalli. When wet, the thallus is bright olive-green. Perithecia are numerous, immersed in the thallus with only the minute round black ostiole visible. Paraphyses surrounding the cylindrical asci gelatinize, becoming indistinct with age. The ascospores are simple, hyaline,

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Table 1. Soil lichen collecting stations and their locations in Iowa.

SITE #	SITE NAME	LEGAL DESCRIPTION	COUNTY
LOESS HILLS PRAIRIES			
1.	Banks Tract	Sec. 20, T91N, R49W	Plymouth
2.	Dahm Tract	W 1/2 Sec. 18, T85N, R44W	Monona
3.	Gleason-Hubel Wildlife Area	Sec. 30 & 31, T81N, R45W	Harrison
4.	Loess Hills Wildlife Area	NW 1/4 Sec. 9 and W 1/2 Sec. 21, T84N, R44W	Monona
5.	Raglan Tract	E 1/2 Sec. 21, T80N, R44W	Harrison
6.	Stone State Park	Sec. 2, T89N, R47W	Woodbury
7.	Waubonsie State Park	E 1/2 Sec. 31, T67N, R42W	Fremont
WESTERN DES MOINES LOBE PRAIRIES			
8.	Anderson Prairie	NW 1/4 Sec. 33, T100N, R34W	Emmet
9.	Cayler Prairie	NW 1/4 Sec. 17, T99N, R37W	Dickinson
10.	Freda Haffner Kettlehole	SW 1/4 Sec. 33, T99N, R37W	Dickinson
HILLSIDE "GOAT" PRAIRIE			
11.	Turkey River Mounds	NE 1/4 Sec. 11, T91N, R2W	Clayton
MISSOURI RIVER FLOODPLAIN			
12.	Tyson Bend Wildlife Area	NW 1/4 Sec. 29, T79N, R45W	Harrison

11-16 × 6-8 μm, 8/ascus.

Following Weber (1963), we consider *D. hepaticum* (Ach.) Th. Fr. and *D. lachneum* to be a single, highly variable species under the latter name. This is a departure from Wetmore (1967) who retains them as separate species on the basis of discrete squamules with ascending margins vs. overlapping squamules with downturned margins, respectively. It is our observation that these differences more often reflect age, weathering, and moisture status of the thallus rather than genetically based morphological differences.

Endocarpon pussillum Hedw.

This species is difficult to distinguish from *D. lachneum* on the basis of external morphology alone. Ascospores are, however, diagnostic. In contrast to the colorless, nonseptate ascospores of *D. lachneum, E. pusillum* has large, dark brown, muriform ascospores that resemble miniature hand grenades. Two ascospores, each 23-45 × 12-18 um, are borne in each clavate ascus. The ostioles of the perithecia often protrude slightly above the surface and appear as raised dots. Perithecial ostioles in *D. lachneum* thalli are nearly always flush with the thallus surface. These two species are the most common members of the western prairie soil lichen group, but the combination of their dull brown coloration and terriciolous habit make them easy to overlook, especially when dry.

Table 2. Soil lichen species of some Iowa prairies and their collection sites.

SPECIES	COLLECTION SITES
Group I	
Collema tenax	1,2,3,4,5,6,7,9,10
Dermatocarpon lachneum	1,2,3,4,5,6,7,9,10,12
Endocarpon pusillum	1,2,3,4,5,6,7,9,10,11,12
Lecidea decipiens	1,2,3,4,5,6,7,10
Group II	
Bacidia bagliettoana	3,4,7,9,10
Caloplaca stillicidiorum	1,3,5,6,9,10
Candelariella vitellina	5,6,9
Cladonia apodocarpa	1,7,8,9,10
Cladonia cariosa	3
Diploschistes scruposus	9,10
Heppia lutosa	7,10
Thrombium epigaeum	2,3,9,10
Group III	
Squamarina lentigera	9,10

Lecidea decipiens Ehrh.

The small squamules of this species are a distinctive bright salmon-pink with white margins. Although this species is widespread, specimens with apothecia are infrequent. The strongly convex black apothecia are borne at the margins of the thallus. The ascospores are simple, ellipsoid, hyaline, 10-16 × 5-7 um, 8 per ascus.

Group II

Bacidia bagliettoana (Mass. and DeNot.) Jatta

The thallus is without obvious differentiation into cortical or medullary layers but forms a gray-green, warty, granulose crust on soil or growing over mosses. The small sessile apothecia are black, becoming convex in age. The slender clavate asci bear 8 acicular (needle-like) ascospores that are several-septate, although the septations are often faint and scarcely visible.

Candelariella vitellina (Ehrh.) Mull. Arg.

The thallus is composed of diminutive, crenately lobed squamules without a strongly delineated upper cortex or medullary layer, bright lemon-yellow to greenish-yellow, attached to the substrate by white rhizines. The apothecia, also yellow, are small, 0.3-1.0 mm in diameter, sessile, with a flat disc and thalline exciple. Clavate asci each contain from 12 to 32 hyaline, ellipsoid, mostly 1-septate, 8-18 × 4-6 um ascospores.

Caloplaca stillicidiorum (Vahl) Lynge

The thin gray to white thallus is granulose, often disappearing with only the conspicuous brightly colored, yellow to orange apothecia remaining. The apothecia are small, sessile, with a flat to convex disc and sometimes with white pruinose margins. Ascospores are polarilocular, hyaline, ellipsoid, 10-15 × 7-9 um, 8 per ascus. This species is found at the soil surface on plant detritus such as the well-weathered rhizomes and culms of prairie grasses.

Specimens were assigned to this taxon primarily because all our collections were found on weathered plant detritus, a substrate recognized by Wetmore (1967) only for *C. stillicidiorum.* This may be somewhat arbitrary because there are 3 other species, *C. pyracea, C.gilva,* and *C. citrina* that appear to closely overlap *C. stillicidiorum* in terms of thallus morphology, apothecia and spore characters, and to be virtually indistinguishable except for slight differences in substrate affinity. The possibility exists that these are not distinct species but, rather, a continuum of ecotypes. It is hoped that future taxonomic revisions in the genus *Caloplaca* will address this question and clarify the relationships among these taxa.

Cladonia apodocarpa Robb.

The vegetative thallus in this species consists entirely of the persistent primary squamules. Margins of the thallus have upturned lobes revealing a chalk-white undersurface that contrasts sharply with the dull ashy-green upper surface. Pycnidia appear as small black dots on the surface of the thallus. We did not observe fruiting bodies in any of our collections, and fertile specimens are rare. Apothecia, when present, are reported to be dark brown and attached directly to the primary thallus.

Chemical Tests: K^+ yellow, KC−, P^+ red (Wetmore, 1967)

Cladonia cariosa (Ach.) Spreng. f. *squamulosa* Mull.

Lobes of the persistent primary thallus are often finely divided to branching, ascendant, green on the upper surface, white beneath. The dark brown apothecia are borne in clusters at the tips of the cylindrical branching podetia. Surface of the podetia is usually deeply fissured and rough textured. Pycnidia may occur on both primary squamules and podetia.

Chemical tests: K^+ yellow, KC−, P− (Wetmore, 1967).

Diploschistes scruposus (Schreb.) Norm.

In this species, the thallus forms a continuous minutely granulose to warty, greenish or ashy-gray crust, with small black, deeply concave, almost crater-like apothecia, 0.3-0.5 mm across, sunken into the thallus surface. At maturity the asci contain 4-6 large dark brown, muriform ascospores, 1-2 septate longitudinally and 3-6 septate transversely, 26-30 × 10-12 um.

Heppia lutosa (Ach.) Nyl.

The large, flat, round thallus squamules, 0.5-1.0 cm, are olive-green or darker, closely adnate to the substrate, with thickened, shallowly lobed margins, and often form dense patches. The contrasting brick-red apothecia are deeply concave with only a thin exciple, giving the thallus an appearance of being pockmarked by rusty brown pits. The ascospores are nonseptate, ellipsoid, 15-25 × 5-10 um, 8 per ascus. The phycobiont is a cyanobacterium.

Thrombium epigaeum (Pers.) Wallr.

The thallus is thin, finely granulose, grayish or bluish-green, partly immersed within the substrate and lacking internal differentiation. The fruiting bodies are perithecia, with the ostioles appearing as raised black dots on the surface of the thallus. Eight hyaline, nonseptate, ellipsoid ascospores are produced in each ascus.

Group III

Squamarina lentigera (G. Web.) Poelt

The thick, foliose thallus is pale gray-green to cream, becoming densely pruinose with age; the surface at the center is broken and chinky-aerolate while the margins are flattened and distinctly lobed. Buff to tan apothecia, 0.5-2.0 mm in diameter, are clustered over the center of the thallus. The apothecia are flat, sessile, with a thin thalline exciple. The ascospores are simple, hyaline, ellipsoid, 10-12 × 4-6 um, typically 8 per ascus.

DISCUSSION

Soil lichens, associated with other prairie elements, are common in the Loess Hills prairies of western Iowa where the sward-forming dominant grasses give way to a more bunched growth form. This difference in growth habit reflects the reduction in average annual rainfall as one moves from east to west across the state. At Dubuque in eastern Iowa, yearly precipitation averages 34 inches and in Sioux City on the western Iowa border, only 26 inches. Consequently, the vegetation cover in western Iowa prairie grasslands is more sparse and has more exposed soil available for colonization.

A low moisture-holding capacity of the loess substrate and the rugged relief accentuate the drying conditions imposed by lower rainfall. Although the loess province extends from the Missouri River east to the Cary Lobe (Oschwald *et al.* 1965), the most spectacular displays of loess prairie are found in the narrow corridor of bluffs fronting the Missouri River (Prior, 1976; Prior *et al.*, this issue). Here, on sheer south and west exposures subjected to drying by westerly winds, the most xerophytic conditions in the state are found (Shimek, 1910). Lichen colonies, apparently well suited to this dry environment, form extensive crusts up to several square meters in diameter.

Prairie remnants east of the Cary Lobe also may have soil lichen floras like those of the Loess Hills prairies, but only to a limited extent. They are restricted to areas where soil factors create highly localized drought conditions, such as in the goat prairies of the Mississippi River bluffs at Turkey River Mounds (Table 1). The sand prairies, such as at the Big Sand Mounds near Muscatine, support a well developed, diverse lichen flora (Schulten, J., 1983, pers. commun.) but it is a different lichen flora than that of the Loess Hills prairies.

The soil lichen species consistently present in the Loess Hills prairies and on the gravelly morainal ridges of prairies in Emmet and Dickinson Counties in northwest Iowa are the same species reported as components of the cryptagamic earth soils from the grasslands of arid and semi-arid regions of the western United States (Anderson and Rushforth, 1977).

Looman (1964), in his study on the distribution of five lichen communities in the Canadian Prairie Provinces and adjacent parts of the Great Plains, considers the group of species which we have found to be common in the Loess Hills prairies as part of the Parmelietum chlorochroae association. In a transect along the 43rd parallel from Madison, Wisconsin to Douglas, Wyoming, he found soil lichens of this association on bare, mostly calcareous soils in sites with a vegetation cover of less than 50%.

These same squamulose lichens, often the same species of *Dermatocarpon, Psora (Lecidea),* and *Heppia,* have been reported from soils of desert regions throughout the world (Rogers, 1977). In these arid habitats, the crusts of crustose, squamulose, and less commonly, foliose lichens can cover the soil surface and have an important influence on soil stability, water relationships, and fertility (Rogers, 1977).

The commonest species of Loess Hills prairie soil lichens, group I, share several characteristics. Most are densely rhizinate, enabling them to persist on a substrate prone to erosion. Malone (1977) examined the rhizine systems of thalli of *Endocarpon pusillum* growing around the bases of prairie grasses from several sites in Loess Hills prairies. Apparently separate thalli were actually interconnected by a network of rhizines, interpreted as rhizomorphs by Malone. Chains of thalli and connecting lateral rhizomorphs nearly 5 cm long and vertical rhizomorphs nearly 2 cm long were dissected from the soil. Predominately squamulose to subfoliose in growth habit, lichens of this group have individual thalli that are small and compact. In species of this form, surface to volume ratio is reduced and the gelatinous to leathery consistency of the thallus imparts an ability to withstand long periods of desiccation without damage. Reproductive structures such as apothecia have gelatinizing paraphyses that extend over the spore-containing asci. Perithecia have the added protection of being fully immersed within the lichen thallus.

Of the 13 terricolous species that we have identified from western Iowa prairies, two, *Collema tenax* and *Heppia lutosa*, have blue-green phycobionts. Rogers, *et al.* (1966) demonstrated N-fixation by a species of *Collema,* a lichen with a heterocystous blue-green phycobiont. Snyder and Wullstein (1973), examining the role of desert cryptogams in nitrogen fixation, demonstrated that *Dermatocarpon lachneum* thalli associatd with *Nostoc* sp. could fix nitrogen. They also demonstrated N-fixation by the *Nostoc* blue-green phycobiont of *Collema.* Shields (1957) and Shields *et al.* (1957) reported the nitrogen

content of soils with a lichen crust to be higher than that of soils without such lichens. Nitrogen fixation by these soil crust lichens in arid and semi-arid ecosystems could supplement the nitrogen contribution from scattered nodulated legumes.

In summary, Loess Hills prairies of western Iowa have a well developed soil lichen flora. It includes some of the same cosmopolitan species present on the soils of more arid grasslands. The western Iowa prairies are transitional to two major grassland formations, the Mesic Tall Grass Prairie to the east and the drier Mixed Grass Prairie to the west. The presence in the loess prairies of the same lichen species which can be found in greater abundance on the western semi-arid grasslands in association with prairie plants of decidely eastern affinity, gives evidence of overlapping phytogeographic boundaries.

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Key to soil lichens of western Iowa prairies

1. Thallus foliose, squamulose or fruticose. 2
1. Thallus granulose-crustose or disappearing entirely with only the bright yellow to orange apothecia plainly visible. 10
2. Thallus algae blue-green (a cyanobacterium) 3
2. Thallus algae green. 4
3. Thallus foliose, black, gelatinous, lacking internal differentiation and having radiating plicate lobes; ascospores longitudinally and transversely septate . . . . . *Collema tenax*
3. Thallus of thick, flat, olive-green to brown squamules with entire to wavy margins, paraplectenchymatous throughout; ascopores nonseptate . . . . . *Heppie lutosa*
4. Thallus composed of distinct squamules, often upright or with upturned margins 5
4. Thallus foliose, at least at the margins which are deeply lobed, becoming chinky-subaerolate and pruinose in the center with age . . . . . *Squamarina lentigera*
5. Thallus of numerous green to gray-green squamules with upturned margins and white to cream-colored undersurface, often in densely crowded masses . . . . . 6 genus *Cladonia*
5. Thallus of pink, yellow or brown squamules 7
6. Podetia and apothecia lacking, thallus consisting entirely of vegetative squamules . . . . . *Cladonia apodocarpa*
6. Podetia and apothecia present, brown apothecia apical on branched podetia . . . . . *Cladonia cariosa*
7. Squamules lemon yellow, small, crenately lobed, with yellow apothecia . . . . . *Candelariella vitellina*
7. Squamules pink or brown to tan in color 8
8. Squamules bright salmon pink with white lower surface; apothecia, when present, black, borne on the margins of the thallus . . . . . *Lecidea decipiens*
8. Squamules tan to red-brown; fruiting bodies perithecia, the ostioles erupting through the thallus surface as black dots . . 9
9. Ascospores simple, hyaline, 8/ascus . . . *Dermatocarpon lachneum*
9. Ascospores muriform, dark brown, 2/ascus . . *Endocarpon pusillum*
10. Thallus a gray green warty-granulose crust 11
10. Thallus a thin white to gray granular crust, often disappearing, only the conspicuous bright yellow-orange apothecia visible, growing on plant detritus at the soil surface. . . . . *Caloplaca stillicidiorum*
11. Ascospores muriform, dark brown, 4-6/ascus . . . . *Diploschistes scruposus*
11. Ascospores hyaline, one celled or with faint transverse septations 12
12. Spores never septate, ellipsoid, fruiting body a perithecium . . . . . *Thrombium epigaeum*
12. Spores acicular, faintly transversely septate, fruiting body a small black convex apothecium . . . . . *Bacidia bagliettoana*